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Wood Quality Studies to guide Hawaiian Forest Industries

H. H. Smith

Miscellaneous Paper No. 48
April
1960

PACIFIC SOUTHWEST
FOREST AND RANGE
EXPERIMENT STATION
Berkeley - California

in cooperation with
DEPARTMENT OF AGRICULTURE AND CONSERVATION
STATE OF HAWAII

FOREWORD

For many years before Statehood, the Bishop Estate and later the Territorial Board of Commissioners of Agriculture and Forestry of Hawaii conducted a cooperative program of timber testing at the U. S. Forest Service Forest Products Laboratory at Madison, Wisconsin.

In 1959, it became apparent that the time had come to re-examine this program and set a course for future wood quality studies. The Board asked the Pacific Southwest Forest and Range Experiment Station to take on the job, and the Legislature provided most of the necessary financing.

This report is the outcome. It represents one of a series of forest research projects which were started under the old Board and which are now being continued cooperatively by the new Department of Agriculture and Conservation and the Forest Service.

WOOD QUALITY STUDIES

TO GUIDE HAWAIIAN FOREST INDUSTRIES

By H. H. Smith, Technologist
Division of Forest Products Utilization Research

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U. S. DEPARTMENT OF AGRICULTURE--FOREST SERVICE
PACIFIC SOUTHWEST FOREST AND RANGE
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Thirty-two years old, this eucalyptus plantation contains an estimated 40, 000 board feet of harvestable timber per acre.

WOOD QUALITY STUDIES TO GUIDE HAWAIIAN FOREST INDUSTRIES

By H. H. Smith

Hawaii's forests offer a chance to strengthen the Islands' economy through expansion of the present small forest products industry. A high potential for timber growing has been demonstrated by several introduced forest tree species. On favorable sites some stands have reached merchantable size in 40 years or less. But relatively little is known about the wood properties which affect manufacture and use of products from Hawaii-grown timber. Do the introduced species have the same qualities as when grown in their natural range? How do the native and introduced species compare with imported timber products that are used and well known in the Islands?

Some answers to these and other questions have come from studies of the mechanical and physical properties of local woods started about 10 years ago. Few species, however, have been studied in any detail. The U. S. Forest Products Laboratory, at Madison, Wisconsin, has investigated the strength and certain related properties of six species, and some veneer cutting and drying characteristics of two of these. Local manufacturers have studied drying behavior of several species which appear suited for lumber. These studies are a logical starting point but not comprehensive enough to provide an adequate background for industrial development. Other properties affect manufacturing and marketing. Research should also take into account the end-use requirements for wood in Hawaii.

Gathering information on these end-use requirements was the aim of a study conducted in Hawaii in 1959. The study included interviews with large users of wood products, lumber dealers, and sawmill operators. It also included inspection of the major forest land areas to see the type of timber available for commercial use in the coming years. The supply of Island-grown timber was not evaluated because a timber resource survey, now being made by the Pacific Southwest Forest and Range Experiment Station and the State Division of Forestry, will develop this information. What this study sought was information that will help select the species of Island-grown timber for further research on wood properties and help recommend the kinds of studies needed to determine their suitability for certain end-uses.

Lumber dealers are able to remanufacture imported timber products to local specifications.

Typical single-wall house construction using redwood siding—Waialae, Honolulu, Hawaii.

HAWAII USES WIDE RANGE OF TIMBER PRODUCTS BUT FEW SPECIES AND GRADES OF LUMBER

Timber products in all the variety known to commerce are consumed in Hawaii: lumber and plywood for construction, manufacturing, and shipping; poles, piling, and other "roundwood" products; paper, paperboard, and other pulp products. This varied market is being supplied almost completely by imports—all the paper and pulp, all roundwood but a small amount of posts, and all but a small fraction of the lumber.

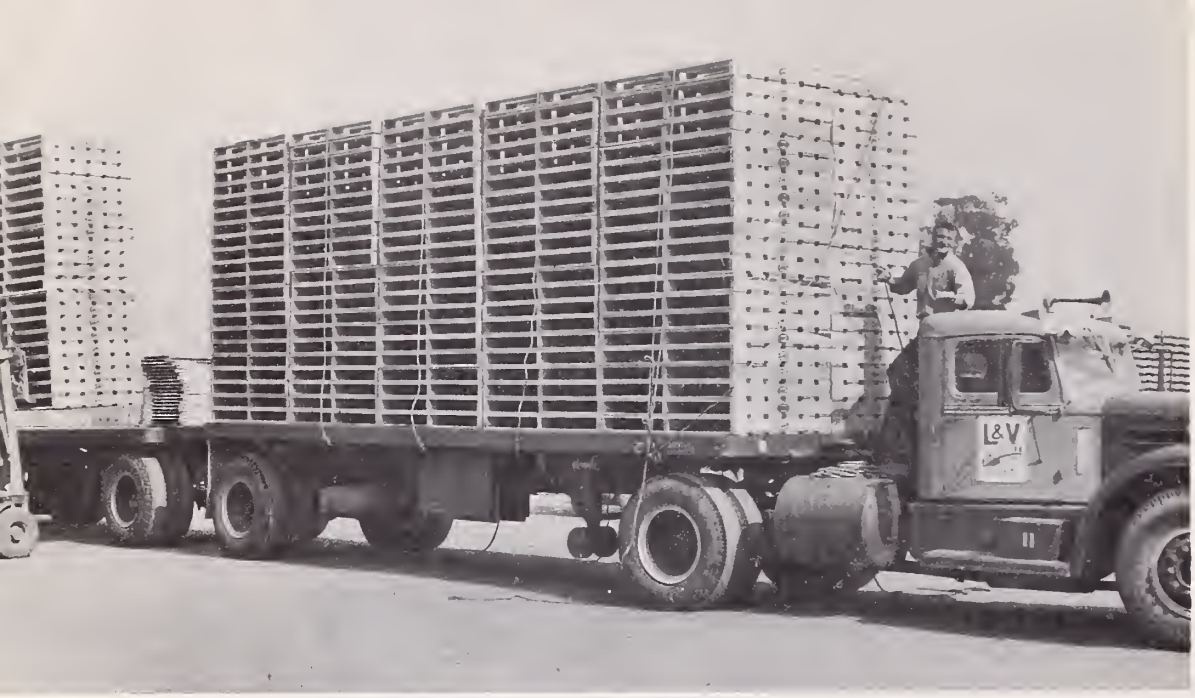
Three timber species—Douglas-fir, redwood, and oak—supply 98 percent of the Islands' lumber requirements. Annual consumption is forecast at 110 million board feet during the next 5 years. Of this amount, 93 million board feet will be used in construction each year, for framing, sheathing, siding, forms, and other purposes. Two-thirds is expected to be Douglas-fir, one-third redwood. Another 10 million board feet of Douglas-fir and redwood will go into flooring and millwork. The remaining 7 million board feet will be hardwood lumber, mostly oak flooring from the mainland and Phillipine lauan.

Lumber imports are also restricted to a few grades. Only higher quality material is considered suitable for the Hawaiian market. The size range is narrow too: mostly 4/4 (inch-thick) boards and dimension lumber in Douglas-fir, 4/4 x 6- and 8-inch tongue and groove siding in redwood, and nominal 1-inch flooring in oak.

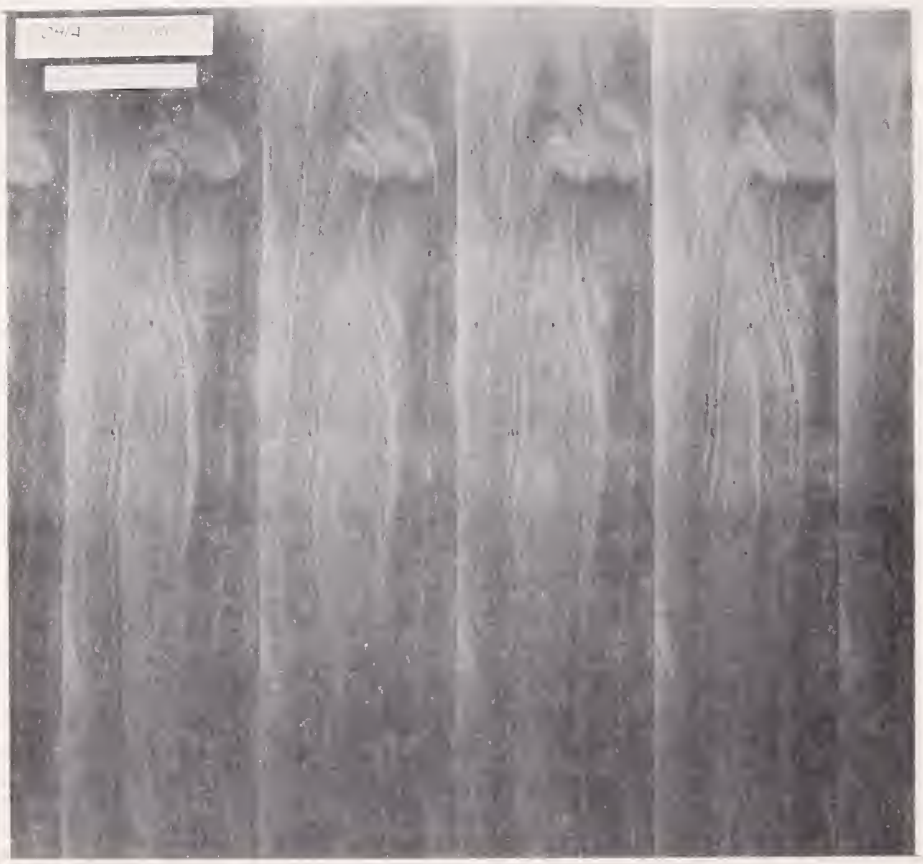
Why is the selection so limited? One reason is the reliance on off-shore sources, which permits buyers to specify only the grades and sizes they want. Then, too, the lack of local producers means that the wide range of grades and sizes usually produced at local sawmills does not have to be fitted into the lumber economy. And high transportation costs require importing of only the better grades, so remanufacturing costs can be held to a minimum.

CLIMATE AND CONSTRUCTION METHODS PLACE A PREMIUM ON STRENGTH, APPEARANCE, AND DURABILITY OF LUMBER

Use conditions in Hawaii also influence the properties desired in lumber. The mild climate permits single-wall construction of dwellings and light commercial buildings. Construction members, siding, framing, flooring, roof decking, and other components are all load-bearing and exposed. Only the best grades of lumber will provide the strength and appearance this type of construction requires. Even 1-inch softwood and hardwood flooring,



Loading pallets at California plant which manufactures 2,000 units each day. Many will go to Hawaii-bound shipments.



Sample panel of Ohia plywood produced during studies at U. S. Forest Products Laboratory.

which in other states is usually laid over a sub-flooring, is laid directly over floor joists and is load supporting. Such use requires long lengths of relatively clear material.

The mild climate also favors development of decay and insect damage in wood. An unusually important requirement for wood used in Hawaii, therefore, is either high natural resistance or preservative treatment against decay and insects. This requirement explains the local preference for all-heart redwood, which has outstanding natural resistance, and for the heartwood of Douglas-fir, which is moderately resistant.

An assured supply of lumber with these qualities, then, is an important consideration in the choice of material for construction. Douglas-fir and redwood from the West Coast are in a good position to meet this requirement. Many established producers can guarantee the quantities of grades and sizes desired. Furthermore, the large lumber yards in Hawaii have equipment for remanufacturing construction lumber to specification as required.

Relatively small amounts of lumber are used for manufacturing and shipping, but these uses are economically important. The manufacture of craft articles and furniture represents one established outlet for locally-grown woods. Monkey pod and koa are the two most used species. The manufacturers provide a valuable nucleus of operating know-how for an expanded forest utilization program.

Much of the lumber used in shipping and material handling stems from mainland purchases by Hawaiian companies. Virtually all containers, pallets, blocking, bracing, and dunnage originate at West Coast ports. Pallets shuttle back and forth between Hawaii and the mainland. Dunnage that originates on the West Coast is discharged in Hawaii, after a free ride, and often is reused, either as dunnage or as locally fabricated containers and pallets.

FEW SPECIAL REQUIREMENTS EXIST FOR OTHER TIMBER PRODUCTS IN HAWAII

In the main, requirements for other timber products used in Hawaii are about the same as for their use in other states, and wood properties of importance are therefore little different in the Islands.

Plywood, here as elsewhere, finds two broad classes of use: a construction type, mostly of softwoods, and a decorative type, predominantly of hardwoods. Island use amounts to about 8

million square feet annually—95 percent softwood, the rest hardwood. Present available island-grown softwood timber is not sufficient to support local production of construction plywood. Some local hardwoods, on the other hand, may prove to be abundant enough and to have suitable properties for high quality decorative plywood. In view of the limited local use (400,000 square feet annually), the bulk of the local output might have to move into offshore markets for furniture, cabinets, and paneling material.

For these uses, appearance is the most important property: the wood must be pleasing to the eye. Other desirable properties are hardness, to resist denting and scratching in service, and relatively low shrinking and swelling with moisture changes, to increase stability of the plywood and to minimize losses during manufacturing. A good wood for veneer and plywood must cut well on the lathe or slicer. The wood must glue and sand well and take a good finish. Manufacturers will also be concerned with properties that affect the handling of veneer logs, bolts, or flitches before they are cut into veneer. Desirable properties include resistance to excessive loss from stain, decay, and insects, and freedom from internal stresses that cause surface-checking and end-splitting during storage and heating.

Although hardwoods appear most promising at present, certain softwoods may find uses once a hardwood plywood operation is established. For example, some may be valuable for specialty items even though the timber supply is limited. Others may be used for core stock to be faced with high grade hardwoods.

Pole requirements in Hawaii, as on the mainland, call for clean, straight, strong, material properly treated to insure long service. The two big consumers are the Hawaiian Electric Company and the Hawaiian Telephone Company. Each uses 800 to 1,000 poles a year, occasionally as many as 2,000. Douglas-fir is the preferred species. Suppliers are West Coast manufacturers who grade, treat, and sell poles to standard specifications. Certified inspectors regrade the poles before shipment to insure compliance to specifications. Consequently a uniformly high grade of poles is used in Hawaii.

The most-used types, by trade classification, are the 40-foot, Class 3 and the 30-foot, Class 5. The power company will use only creosote-treated poles, but the telephone company is interested in trying other types of preservatives on the 25-foot, Class 5 poles used for lead-in lines. Telephone linemen prefer a "clean" pole, one treated with a water or oil-borne preservative rather than creosote.

Hawaiian wood-treating plant equipped to pressure treat lumber, poles, and posts. (Photo courtesy Honolulu Wood Treating Co., Ltd.)

Hardwood logs from plantations of silk-oak about 65 years old. (Photo courtesy Myron S. Wold)

Current consumption of posts and piling is not known. Most posts are produced locally. The naturally durable species, such as algaroba, are preferred; they are seldom treated. Just now the demand for fence posts is being met from a relatively large but temporary supply of used railroad ties from abandoned lines, and the post market is far from normal.

Requirements for marine piling are extremely rigorous. Only thorough protective measures, such as a full-cell creosote treatment, will enable wood to resist attack by marine borers and provide satisfactory service. Use of local species, then, will require installation of treating facilities of a type not now present in Hawaii. Several species of eucalyptus are now available in the right lengths and size classes for marine piling, if treated, and they would be satisfactory for foundation piling without treatment if used below the water table. Piling may come into more frequent use as buildings are erected on filled land along the waterfront of Honolulu.

Pulpwood or pulp chips have no local market, but one might be developed at the existing or future "soft-board" plants, by using wood to supplement the bagasse which is now the raw material.

INDUSTRIAL EXPANSION HINGES ON DEVELOPMENT OF HARDWOOD MARKETS

If an Hawaiian timber products industry is to be established in the near future, it will have to be based mainly on the hardwood timber which now exists. The Forest Survey will determine just how extensive this resource is. But, even without precise survey estimates, the timber supplies now available are obviously concentrated in the native and introduced hardwood species. Some softwood logs can be harvested from some plantations, but there are not enough softwood sawtimber trees to support an industry.

At first glance this seems like an anomalus situation. Since the import figures show that Hawaii uses softwoods mostly, how can a hardwood-based industry develop and survive?

The answer is that an Hawaiian timber products industry can flourish only through trade with off-shore markets. Any experienced businessman who is thinking about manufacturing Hawaiian woods will realize this. He will want to make his own market investigation and consult the existing public and private sources of information. The difficulty is that no information on potential markets exists. At the Chamber of Commerce timber conference in Honolulu early in 1959 great stress was placed on the need for an economic study of timber industry potentials.

This report is not meant as a substitute for the detailed market data required to attract investors. Rather, it emphasizes the timber quality studies which are needed even before all of the marketing alternatives can be explored.

Nevertheless, it seems likely that the major market for Hawaiian hardwood lumber, veneer, and other products will be found on the mainland. The western states have little hardwood timber; most of it is east of the Mississippi River. Eastern hardwood manufacturers have certain advantages: A wide variety of accepted species, long experience and technical know-how, and established trade channels. On the other hand, the Hawaiian trees can be grown in less time than most eastern trees; high-quality eastern hardwoods are relatively scarce; Hawaiian shipments can be made by water; West Coast markets are growing rapidly; and Hawaii can produce a differentiated product which cannot be produced easily on the mainland.

In addition there may be more local market opportunities than the import figures reveal. For one thing, imported lumber is usually high grade and limited in sizes and thicknesses. Hardwoods cannot be substituted in every use (for example, hardwoods generally weigh more than softwood; they are frequently too heavy for construction, dunnage and containers, but they are preferred for pallets). However, local hardwoods may be able to compete successfully with softwoods when high-grade material is unnecessary but price is an important factor. Because low-grade hardwood lumber seldom can be transported very far, the development of local markets for low grade products could be a particularly crucial factor in the establishment of the industry in the Islands. Then too, the established craft industry will no doubt expand to meet demands of the tourist trade.

No one, of course, yet knows how these markets can be exploited. Much depends upon the costs of production and transportation which an Hawaiian timber products industry would incur, the selling prices which it could obtain relative to competitive woods, the investment it might have to make in order to secure consumer acceptance, and the health of the economy.

These factors cannot be evaluated here. They will have to be considered separately and soon, but the first job is to find out what Hawaiian woods are good for.

WOOD PROPERTIES RESEARCH RECOMMENDED FOR PROMISING HAWAIIAN TIMBER SPECIES

Both the end-use requirements for timber products in Hawaii and the possibility of export trade suggest that study of Hawaii-grown timber species should go well beyond evaluation of

Manufacture of craftwood products is a well established industry catering especially to tourist trade.

Soil block tests show relative durability of wood samples.

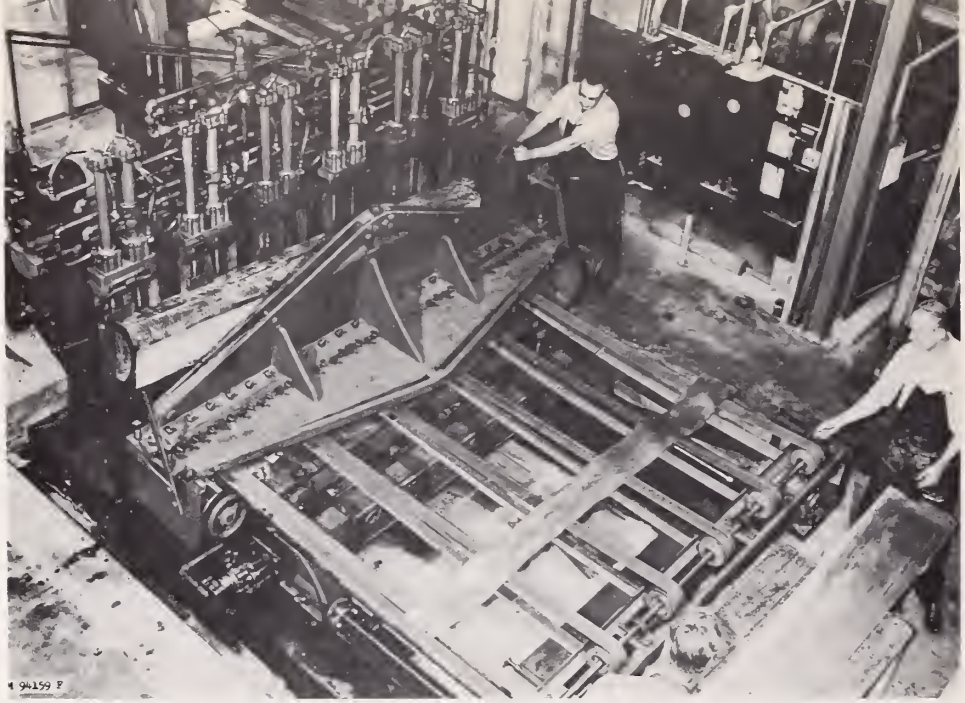
strength properties. Some of the woods will be used where other properties are important: appearance of figure, drying characteristics, and suitability for veneer cutting, machining, and gluing.

Sometimes rather special qualifications may suit a wood for a particular use. A striking example is monkey pod, which is the most important wood in the craft industry because of a very fortunate combination of two outstanding properties: appearance or figure and low shrinkage. These two properties are important for any craftwood--far more important than high strength.

Particularly critical are the many use requirements in Hawaii which call for a high degree of resistance to decay and insects. Few woods have enough natural resistance to permit use without protection. Therefore studies of Hawaiian woods should determine not only their natural resistance to decay and termites, but also whether preservative treatment will protect the wood in high hazard conditions. Modern research techniques have made such tests less time-consuming. The soil block test is a promising new method for studying natural resistance and screening wood preservatives. New exposure techniques standardize and help speed studies of resistance to termites.

Application of results can be speeded by interpreting the results of wood property studies in terms of potential uses for the wood. For example, a good deal is known about the properties of Hawaii-grown shamel ash (Fraxinus uhdei), often called Mexican ash: static bending, hardness and toughness, specific gravity, and shrinkage. These figures have been compared with those of species for which shamel ash might be considered a replacement such as Philippine lauan for paneling and cabinet work or white ash for handles. Thus, we know that shamel ash grown in Hawaii is sufficiently strong for furniture and similar uses, but not for implement handles requiring exceptional strength. Two Hawaii-grown trees--toon, called toona locally, (Toona ciliata var. australis) and cigarbox cedrela, sometimes called Hawaiian cedar, (Cedrela odorata)--have been suggested for use as vertical siding in single-wall construction. A direct comparison with heart redwood as to strength, shrinkage, paintability, and resistance to destructive pests would go a long way toward determining how these two species should be used. Comparisons of this type are a definite aid in introducing new species because the information is easily interpreted by agencies responsible for compliance with codes and specifications.

So far, six Hawaii-grown woods have been studied mostly as to their strength properties (table 1). Some of these species were studied in greater detail than others. The testing



Equipment for veneer slicing studies at U. S. Forest Products Laboratory.

Table 1.--Scope of past studies by U. S. Forest Products Laboratory on Hawaii-grown woods[1/]

Properties	Ohia (11 trees)	Eucalyptus multiflora (10 trees)	Toon (5 trees)	Shamel ash (5 trees)	Cigarbox cedrela	Redwood (5 trees)
Strength						
Actual	Green & dry	Green & dry	Limited green & dry	Limited green & dry	Explora-tory	Limited green & dry
Comparative	No	No	No	Yes	No	No
Drying	Explora-tory	No	No	No	No	Explora-tory
Machining	Explora-tory	No	No	No	No	No
Veneer cutting and drying	Explora-tory	Explora-tory	No	No	No	No
Natural dura-bility	No	No	No	No	No	No
Treatability	Explora-tory	No	No	Explora-tory	No	Explora-tory
Pulp & paper	No	No	No	No	No	No

1/ Common and botanical names are taken from Kelsey, Harlan P. and Dayton, William A., Standardized Plant Names, 2d-Ed., Harrisburg, Pa., 675 pp., 1942, in the interest of providing a recognized source for reference purposes.

program usually included specific gravity, shrinkage, static bending, impact bending, compression, and hardness. For Ohia and E. multiflora, shear, cleavage, and tension perpendicular to the grain were also studied. These species, and others which have not been studied but show much commercial promise, deserve additional attention to determine properties related to their possible end uses.

(1) Metrosideros polymorpha--OHIA

Ohia is the most abundant native species in Hawaii. It is a close-grained, heavy, dense wood of reddish-brown to dark brown color. These properties may make it valuable for special uses. Veneering tests show that Ohia makes a beautiful, dense face veneer suitable for cabinet work, paneling, and furniture, although manufacturing problems may develop because of the shape and size of logs and the abrasive properties of the wood. Ohia veneer would also be excellent for the face ply of plywood flooring. Use as lumber, however, may be limited by the irregular form and small size of most Ohia trees. These factors and its high specific gravity pose some difficulties in sawing and drying lumber. Nevertheless, its strength, color, and hardness may make Ohia suitable for special items of cut stock. It may also be suitable for use as poles, posts, or piling.

Mechanical and strength properties of green Ohia were studied at the Forest Products Laboratory and reported in July 1958. Further research on physical properties would help overcome sawing and drying difficulties and exploit Ohia's desirable properties. The following studies are suggested:

1. Machining
2. Drying
3. Natural resistance to decay and termites
4. Preservative treating

(2) Eucalyptus multiflora (Syn. E. robusta)--BEAKPOD EUCALYPTUS

Also known as browngum and swampmahogany, this species was planted extensively in early reforestation and has grown to good size. (Sydney bluegum eucalyptus (E. saligna) is another of the several eucalyptus planted that has some prospect of utilization). E. multiflora is a heavy, strong wood of red or reddish-brown color. Dense and close-grained, it has been used in Hawaii for flooring even though high shrinkage makes it difficult to handle during logging, milling, and drying. It is best suited for those applications where high strength is important.

Studies of both green and dry wood, published by the Forest Products Laboratory in July 1959, provide good figures for the strength and related properties such as weight and shrinkage. Veneering studies, though only exploratory, show that excellent face-grade veneer of E. multiflora can be produced. These studies all point up the fact that this species has some excellent properties and some that will make it difficult to handle as lumber. More information on other important physical properties may indicate high-value end uses that will greatly facilitate the utilization of this species. Such studies would include:

1. Natural resistance to decay and termites
2. Preservative treating
3. Drying
4. Machining
5. Pulping, to supplement information now available on California-grown E. globulus and Australia-grown eucalyptus species.

(3) Toona ciliata var. australis--TOON

Toon, or toona, is making excellent growth in a few Hawaiian plantations and is one of the more promising introduced species. Wood from trees grown in their native habitat is prized as a cabinet wood and for paneling and interior trim. It is reported to be durable and in many ways equal to the best mahogany. Limited experience with locally grown toon indicates that it should be at least equal to the Philippine lauans for cabinet wood. The locally grown wood has also been suggested for certain types of construction, such as exterior siding in single-wall construction.

Judging from figures on specific gravity and shrinkage published by the Forest Products Laboratory in May 1959, Hawaii-grown toon appears equal to that grown elsewhere and should be excellent for the same high value end uses. Further studies of the physical properties are needed to verify these conclusions and determine other qualities. Recommended studies to determine its value as a cabinet wood include:

1. Lumber drying
2. Machining and finishing
3. Gluing

Recommended studies to determine its value as a construction wood include:

1. Natural resistance to decay and termites
2. Preservative treating
3. Paintability

In addition, studies of veneer cutting and drying may show a potential for high grade plywood for cabinet work and decorative paneling.

(4) Fraxinus uhdei--SHAMEL ASH

Shamel ash is another introduced species that has shown great promise in Hawaiian plantings. It has good form and growth rate and is reseeding naturally. Its wood appears excellent for those uses where a light colored hardwood of medium weight and strength is required, including furniture, cabinet work, general millwork, and decorative paneling.

Both actual and comparative strength properties are available from past studies at the Forest Products Laboratory, so potential users can judge the properties of this wood as compared to woods already in use. Shamel ash from Hawaii was found to be stronger and tougher than its specific gravity would indicate. It does not compare with white ash in these properties and therefore will not be as suitable for high-strength uses, such as in implement handles and athletic equipment. Because of its low shrinkage and high strength-to-weight ratio, however, it may have other special uses.

Information is needed on other physical properties of this species to help determine its suitability as a general cabinet wood and possible special high-value uses. The following studies are recommended:

1. Machining
2. Lumber drying
3. Natural resistance to decay and insects
4. Preservative treating
5. Veneer cutting and drying

(5) Cedrela odorata--CIGARBOX CEDRELA

Cigarbox cedrela is still another hardwood species that shows great promise in young plantings. Little timber is of merchantable size at present, but trial plantings look so encouraging that some exploratory milling has already been done. Cedrela odorata from tropical America and the West Indies is used for general millwork and paneling. If Hawaii-grown timber proves to be equally good, it will no doubt find similar uses. One or more outstanding physical properties may indicate special high-value end uses.

Studies of its strength and related properties are needed, in spite of limited present supplies, to measure its potential as a species for afforestation. Studies in the same detail as those made at the Forest Products Laboratory for shamel ash would be helpful. Also, the following physical properties should be determined:

1. Lumber drying
2. Machining and gluing
3. Natural resistance to decay and insects
4. Preservative treating
5. Paintability
6. Veneer cutting and drying

(6) Sequoia sempervirens--REDWOOD

A few forest areas in Hawaii have similar growing conditions to the redwood region of California. Uses for young-growth trees in Hawaii are not likely to be the same as those for the clear, all-heart redwood lumber now widely used in Hawaii. Clear, all-heart redwood is select material from old-growth timber. It is outstanding for house siding because of the grade as well as such desirable properties as low shrinkage, natural durability, paintability, and general good appearance. Plantation-grown redwood in Hawaii is most likely to yield lumber similar to the grades cut from young-growth redwood in California. There, this type of timber yields primarily utility items--2 x 4 framing, 2 x 6 and 2 x 8 decking, and common lumber. Plantation-grown redwood may also prove less valuable than old-growth lumber on other counts; lower natural resistance to decay and insects, and lower rating in paintability because of wide growth rings.

The strength and related properties of Hawaii-grown redwood were studied at the Forest Products Laboratory and reported in May of 1955. Small specimens of clear wood cut from this timber were found to be stronger than young-growth redwood from California, and in some strength properties superior to high specific gravity old-growth redwood. The shrinkage figures for the fast-grown plantation redwood were also favorable, even for longitudinal shrinkage, which is sometimes greater in fast-grown wood than in older, slower-grown wood.

Further study of strength properties is not advisable at this time because the Hawaiian timber is unlikely to yield much of the clear, select grades. Studies of lumber yields and grade are more needed than studies of the strength properties of clear wood specimens. Studies of other physical properties should be directed toward using plantation-grown redwood as a construction wood.

The following order is suggested:

1. Resistance to decay and insects
2. Preservative treating
3. Paintability
4. Lumber drying

(7) Grevillea robusta--SILK-OAK

Silk-oak appears to be one of the more promising timber species in Hawaii even though locally grown wood has not been studied. In Australia, native-grown wood is esteemed for cabinet work, plywood, and construction. Sawmilling trials in Hawaii have produced good material for paneling, furniture, and other uses. The wood is known in the lumber trade as silkyoak. The strength and related properties of Hawaii-grown silk-oak should be studied in about the same detail as has been done for shamel ash. Comparative strength figures would be helpful. Also, studies of physical properties are recommended in the following order:

1. Machining
2. Lumber drying
3. Natural resistance to decay and insects
4. Preservative treating, particularly with a clean preservative since probable end-uses will require painting or natural finishes
5. Paintability
6. Veneer cutting and drying

(8) Alnus nepalensis--NEPAL ALDER

Nepal alder appears to be a good wood for furniture, general cabinet work, and core stock. The strength and related properties should be studied as outlined for silk-oak.

(9) Flindersia brayleyana--BRAYLEY FLINDERSIA

This species, sometimes called Queensland-maple or maple silkwood, falls into the same classification with silk-oak and alder as to end uses, and studies as outlined for these two species are suggested.

Two or three species of pine and other softwoods such as araucarias are known to grow well in the Islands. Studies of the properties of these softwoods are needed to compare them with timber grown elsewhere to help determine their value in reforestation. Utilization of these softwoods will be principally in construction, so that information on strength properties will be important. As the industry develops, it will also need information on lumber yields and grades and on other properties related to construction uses.

Pines and other softwoods are planted on sites where hardwoods are difficult to grow.

RESEARCH AND ACTION NEEDED NOW, PLANNING NEEDED FOR THE FUTURE

To guide the development of a timber products industry in the Islands, these are the steps which must be taken now:

1. Survey the existing timber resource. This is being done.

2. Find out how Hawaii-grown timber can be used and how it compares in utility with other woods. This report tells where such information exists and where it is lacking. A follow-through is needed, with research on wood properties and the quality of logs and lumber grade yields.

3. Explore market opportunities. This is the objective of the economic study recommended by the 1959 Timber Conference. A start can be made anytime, without waiting for all timber quality and quantity information to become available.

4. Disseminate the results of the above research studies and promote the establishment of new industries. This is a job for industrial development agencies, both public and private.

For the more distant future, further planning is needed. Several questions must be answered. In particular, Hawaii must decide what kind of a timber industry it wants. What it gets in the next few years will be dictated by the kind of timber that is ready to harvest. The demonstrated growth potential of the forest lands, however, suggests that other species may be introduced. Before

much more tree planting is done, decision should be reached as to whether Hawaii will support a hardwood industry, a softwood industry, or both.

Entrance into offshore markets will afford a broad choice of species for reforestation. If they are not limited to local markets, land managers can plant the most profitable among suitable species. Each forest area can be planted to produce its greatest return. Site qualities of land available for reforestation will determine which species can be grown. Some sites, such as in the fringe area on the dry side of Molokai, will not grow good hardwoods, therefore pine is planted. On other sites, hardwoods will offer the best prospects for a high volume, high value forest.

For some time to come, softwoods grown in Hawaii will compete with high grade lumber from old-growth timber from the West Coast. Hardwood markets, on the other hand, do not discriminate in favor of old growth. Grade for grade, lumber from young-growth hardwood trees commands the same price as lumber from old-growth trees. The highest grades, though only part of the total yield, bring from $600 to $800 per thousand board feet, and, for certain sizes and grades of teak, true mahogany, black cherry, and black walnut, more than $1,000. Lumber from fast-grown plantation teak is now accepted on a par with lumber from old-growth forests. The present price for teak in San Francisco is $1,300 per thousand board feet.

Hawaii enjoys a unique opportunity: to guide the development of a new industry to produce wood for trade and local use and at the same time, through multiple-use management, to enhance the watershed, recreation, and other resource values of its forest lands. Timber quality studies play an important role in bringing about this development. They will aid in selecting the timber species with the greatest potential for profitable returns.